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Psychological Bulletin

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THE

PSYCHOLOGICAL BULLETIN

WHOLE-PART PROBLEM

BY GRACE O. McGEOCH

Stephens College

The first experimental study of the whole-part problem was published by Steffens (31) in 1900. In the thirty years since that time some 30 other investigations have been published, but no general agreement on the problem has resulted. The apparently conflicting results and conclusions call for a careful re-evaluation of the experimental data. Classification of the data, heretofore, has been mainly on a numerical basis of investigators, experiments or subjects, with confusing and contradictory results. To aid in the clarity of a critical review of the literature, the experimental data have been here summarized on the basis of the types of learning materials used and will be discussed under the following headings:

I. Serial Nonsense Syllables—Adults and Children—Learning.
II. Serial Nonsense Syllables—Adults and Children—Retention.
III. Paired Associates—Adults and Children—Learning and Retention.
IV. Poetry—Individual Experiments—Adults—Learning.
V. Poetry—Individual Experiments—Adults—Retention.
VI. Poetry—Individual Experiments—Children—Learning and Retention.
VII. Prose—Individual Experiments—Adults and Children—Learning and Retention.
VIII. Poetry—Group Experiments—Adults and Children—Learning and Retention.
IX. Acts of Skill—Adults—Learning.

Experimental conditions and technique in the studies grouped together in one table were not identical but were similar enough to

justify comparisons. Throughout the tables, experiments are listed in chronological order, and P always means a pure part method, while variations of the part method, such as progressive part, will be so indicated. It should be noted that all of the adult subjects used, with four possible exceptions, were either college students, undergraduates or graduates, or college professors, and therefore presumably of above-average intelligence.

I. Serial Nonsense Syllables—Adults and Children—Learning

Table I summarizes the work on learning of nonsense syllables in serial form to complete mastery under conditions of massed practice. Before considering these studies separately, it should be noted that Wylie's experiment (No. 7) is the only one in which a sufficient number of subjects was employed to obtain statistically reliable results. In all the other studies, although numerous records were obtained on each individual, particularly in the investigations of Steffens (No. 1), Pentschew (No. 2) and Meyer (No. 6), the number of subjects was so small that the results can be considered only as tendencies observed in a few individual cases.

Inspection of Table I reveals that three investigators, Steffens (No. 1), Pentschew (No. 2) and Wylie (No. 7) found the whole method superior to a pure part with adults, while the experiments of Meumann (No. 3), Reed (No. 4) and Pechstein (No. 5) gave the opposite result. Analysis of these studies suggests that the discrepancy might be, to some extent, a function of the amount of practice. Individual scores in Steffens' experiments are the averages of from 40 to 85 lists, while Pentschew's subjects were given preliminary practice before the 4 to 10 lists on which his individual scores were computed. Ebert and Meumann's subjects, however, learned only 12 lists by a given method, while Pechstein's subjects each learned only one list. The exact number of lists on which the scores for each of Reed's subjects were computed is not given in his article (27), but it was probably not as large as that used by Steffens or Pentschew, since each of his subjects learned on the average a total of 42 lists distributed over four different learning methods. That practice favors the whole method is brought out in two of Steffens' experiments. In her ninth series (31, p. 341), the subject's score based on the first 25 lists learned showed a slight advantage for the pure part method, but this advantage shifted to the whole in the last 60 lists. The same tendency appeared in the 18th series (31, p. 354), in which there was practically no difference between the methods in

TABLE I

SERIAL NONSENSE SYLLABLES—INDIVIDUAL EXPERIMENTS—LEARNING TO COMPLETE MASTERY

(A) *Adults*

Author	S's	Length of List	Lists per Method	Methods	Superior Method: Time Scores	Superior Method: No.*
1. Steffens	2	12–20	40–85	W and P	W	All 5/5
2. Pentschew	5	12–24	4–10	W and P	W	All 10/10
3. Ebert and Meumann	6	12	12	Mixed 3×4 Mixed 2×6 P W	Decreasing order of superiority under "Methods"	All 1/1
4. Reed	8	12	?	Mixed 3×4 P Mixed 2×6 W	Decreasing order of superiority under "Methods"	?
5. Pechstein	6	32	1	W and P Prog. P Dir. Repet. Rev. Repet.	P superior to W Prog. P best	?
6. Meyer	5	12–24	10–40	W Irreg. P	W	All 2/2
7. Wylie†	162	8–24	12	W and P	W	Majority

(B) *Children—Ages 8–14*

8. Pentschew	5	8–15	14–16?	W and P	P	All 6/6

* The numbers after "All" indicate the number of experimental series in which the method was superior with every subject.

† Wylie obtained the same results with lists of 8, 16 and 24 three and four letter words.

the first 30 lists, but a slight advantage for the whole in the last 30. In Wylie's experiment (No. 7), designed to test the influence of the practice factor, the advantage of the whole over the part increased with practice in the majority of cases. The unpracticed whole method, however, was superior to the practiced part method. In contrasting this immediate advantage of the whole method found by Wylie with the results of Meumann, Reed and Pechstein, it must be remembered that all experimental conditions are not identical in any two of these four studies, so a direct comparison is impossible, and that Wylie's results have greater statistical reliability on the basis of the larger number of subjects used.

Under his experimental conditions in which the subjects, with both methods, were instructed to recite as soon as possible, Meyer (No. 6) found the whole consistently superior to an irregular part method. The advantage of the whole was apparent in the learning of the first 10 lists. His results, however, are not comparable to those of the other studies in Table I because of the recitation factor.

It should be noted that, although the pure part in Meumann's and Reed's experiments proved superior to the regular whole method, a mixed method (classed as a modified whole method by Meumann, but a modified part method by Reed) was the most efficient of the four methods used, while a modified part method (progressive part)

in Pechstein's study proved superior to all other methods employed. The relative efficiency of the whole vs. the part method is thus a function of the particular form of the whole and the particular form of the part method which are being compared.

Pechstein's result (No. 5) with lists which are longer than those in any other study brings up the factor of length of material: the advantage of the whole method with lists as long as 24 syllables (Pentschew and Wylie) might give way to a superiority of the part method with lists of 32 syllables. It should be remembered, however, about Pechstein's experiment that it is the only one in Table I in which each subject did not learn by all of the methods indicated. Pechstein compared methods which were used by different subjects. This method of equated groups is justified when the groups are large and are actually equated. However, Pechstein's groups are not only small (six to a group) but their equality was simply assumed on the basis of the fact that no subject had "had earlier experience with the learning material" (**22**, p. 382). Moreover, each subject's score is based on the learning of but one list.

Pentschew's results (No. 8) with children bring out clearly the factor of age; although all of his adult subjects found the whole superior to the part, all of his children show a consistent superiority of the part method.

This analysis of the individual experiments upon the learning of nonsense syllables in serial form suggests the relative efficiency of a learning method to be a function of at least the following factors: practice, form of the learning method, age of subject and length of list.

II. Serial Nonsense Syllables—Adults and Children—Retention

The results of retention tests on the learning experiments in Table I are summarized in Table II. The variety of results in the last column shows clearly that the superiority of a method is a function of the method of measuring retention. Pentschew (Nos. 1 and 7), Meumann (No. 2) and Reed (No. 3) tested retention by relearning, but such a technique yields three different criteria of efficiency: R scores, the number of repetitions required to relearn; C scores, the total number of repetitions in both learning and relearning; and S scores, the saving score in repetitions. Pentschew computed both R and S scores, but his conclusions (**25**, p. 524) that the whole method is superior in retention is based mainly on R scores. Meumann's conclusions (**6**, p. 198) that the regular whole method,

although inferior in learning, is superior to the pure part in retention is based on S score data. Reed, however, questioned (29, p. 592) the reliability of the saving score on the logical grounds that, since it

TABLE II

SERIAL NONSENSE SYLLABLES—INDIVIDUAL EXPERIMENTS—RETENTION

Author	No. of Exper. in Table I	Interval	Super. in Learning	Superior Method * R	C	S
(A) *Adults*						
1. Pentschew	2	24 hrs.	W	W–7 P–2 Same–1	W–10	W–2 P–4 Same–4
2. Ebert and Meumann	3	24 hrs.	Mixed	Mixed	Mixed	W
3. Reed	4	24 hrs.	Mixed	Mixed	Mixed	W
4. Meyer	6—Lists of 12 N.S.	15 min.	W	Recall score W 4/5		
5. Meyer	6—Lists of 24 N.S.	15 min.	W	Recall score W 2/2		
6. Wylie	7	24 hrs.	W	Recall score—not decisive		
(B) *Children*						
7. Pentschew	8	24 hrs.	P	W–6	P–6	W–3 Same–3

* "R" stands for relearning score, "C" stands for the composite score, learning plus relearning, and "S" stands for saving score, $\frac{L-Rel.}{L}$. The numbers after Pentschew refer to experimental series, while after Meyer to subjects.

depends upon the relative differences between the learning and relearning scores, it does not take into account efficiency as measured by the amount of work done per unit of time. He maintained that the most economical method of retention of lists of nonsense syllables is that in which both learning and relearning are accomplished in the shortest time. (Time and repetition criteria are interchangeable in Pentschew's, Meumann's and Reed's experiments, since in each series the rate of presentation of each syllable is constant and the lists are all of the same length.) The C scores, computed by Reed for his and Meumann's data, show the pure part and mixed methods to be superior to the regular whole. Greater consistency is obtained in Pentschew's data in the C scores, computed by the writer, according to which, as in Meumann's and Reed's data, the method which proved superior in learning is also superior in retention.

III. Paired Associates—Adults and Children—Learning and Retention

In Table III are summarized the experiments upon learning and retention of paired associates. All results are in terms of right associates, except in Pechstein's study, in which time, trials and errors are the criteria of learning under his complete mastery conditions. In Brown's investigation (No. 4), which, it should be noted, is the only one yielding statistically valid results, the whole method

TABLE III

PAIRED ASSOCIATES—ADULTS AND CHILDREN—MASSED PRACTICE

I. *Learning*

(A) *Forward Association*

Author	No. and Age of S's	Material	Lists per Method	Practice	Methods	Superior Method
1. Ephrussi	9 adults	5–6 pairs N.S.–N.S.	12–72	10–12 reps.	W P(d)	P(d) with all 5 S's in 9/9 series.
2. Ephrussi	4 adults	8 pairs Word–Number	8–12	6–15 reps.	W P(d)	W with all 4 S's in 9/10 series.
3. Pechstein	6 adults	16 pairs N.S.–N.S.	1	Complete mastery	W and P Prog. P Dir. Rep. Rev. Rep.	Prog. P best. P superior to W by 3 criteria.
4. Brown, W.	511 adults	12 pairs Eng.–N.S.	1	12 reps.	W P	W in 4/4 groups in 3/4.*

(B) *Reverse Association*

5. Ephrussi	2 15 & 16	8 pairs Rus.–Ger.	6–10	16 reps.	W P(d)	P(d) with both S's.
6. Ephrussi	2 adults	8 pairs Word–Number	8–12	6–15 reps.	W P(d)	P(d) with both S's.
7. Neumann	5 9½ & 10	7 pairs Fr.–Ger.	7–10	15 reps.	W and P Mixed	W superior to P—all S's in 4/4 series.
8. Neumann	"	"	10	Time 4'–15"	W P	W with all S's.
9. Neumann	1 9 yrs.	8 pairs Lat.–Ger.	12	10 reps.	W and P Mixed	W superior to P in 2/2 series.

II. *Retention—Reverse Association*

10. Ephrussi	3 adults	8–12 pairs Rus.–Ger.	8–18	9–12 reps.	Interval 24 hrs. 24 " 48 " 72 "	P(d) superior to W with all S's.
11. Neumann	Retention on No. 7 above in two series with 10 lists per method				24 " 48 " 72 "	W superior to P throughout with all S's.
12. Neumann	Retention on No. 8 above				24 " 48 " 72 "	W superior to P throughout with all S's.
13. Neumann	Retention on No. 9 above				24 " 48 " 72 "	W superior to P throughout in both series.

* Statistically valid.

is superior to the pure part in the learning of 12 English words paired with two syllable nonsense words by college students when forward association was tested. Brown considered his experiment a reproduction of Neumann's, although the two investigations differ in number and type of pairs used, age of subjects and type of association required, and he interpreted his results as confirming those of Neumann (Nos. 7, 8 and 9).

Before analyzing Ephrussi's results, it should be noted that her part method is not a pure part, but a mixed method which embodies advantages of both methods. The writer has called it a distributed part, since successive repetitions of each pair were distributed through the practice period. For example, when "W" (total number of repetitions) was 15 and "H" (number of successive repetitions) was 5, each pair in the list was given five successive repetitions

before the next pair was presented. The whole list was gone through three times in this way. The discrepancy in results between Ephrussi's first two experiments (Nos. 1 and 2) she explained on the basis of the difference in the familiarity of the material used, and concluded (7, p. 167) that: (1) with unfamiliar material, such as nonsense syllables, two processes of learning occur, first, the perception and pronunciation of each member of each pair, and, second, the establishment of a bond between members of a pair; (2) the part method furnishes a more favorable opportunity for the first process than the whole method, so the second process can begin sooner with the part; and (3) with familiar material, such as vocabulary and word-number pairs, the relative economy of the whole and part methods is determined by factors which play a secondary rôle in unfamiliar material. The type of association—whether forward or reverse—was indicated by Ephrussi as one such factor, since, with " familiar " material, she found the whole method superior with forward association (No. 2) and the part method superior with reverse association (Nos. 5, 6 and 10). The only legitimate comparison here, however, is between the two experiments (Nos. 2 and 6) in which the same material, word-number pairs, was used with both forward and reverse association. Since no experiments were conducted on forward association with Russian-German vocabulary, it obviously cannot be concluded that the superiority of the part method here (Nos. 5 and 10) with reverse association is a function of the type of association tested. Moreover, it should be noted that Neumann (Nos. 7, 8 and 9) found the whole method superior in reverse association, although a direct comparison is not valid because of the differences in age of subjects and vocabularies used.

Ephrussi found in her fourth series (7, p. 73) with an adult using 5 nonsense syllable pairs, that practice favored the whole method, since in the learning of the first 36 lists the part was superior by 3 per cent, but in the second 36 lists the whole method had become more efficient by 8 per cent. The factor of practice is brought out also by Neumann, who concluded (19, p. 172) from an analysis of his data that practice benefits the whole method more than the part. Such indications can be considered only as tentative suggestions, but they are confirmed by the following re-working of Brown's published data (No. 4) which also indicates that the superiority of the whole method over the part is increased with practice:

		Difference between the 2 methods in favor of the W
List		
A	When employed first	.24
	When employed second	.75
	Increase in advantage of W	.51
B	When employed first	.15
	When employed second	.74
	Increase in advantage of W	.59

The reliability of these differences, however, cannot be computed from the data published.

Neumann concluded, on the basis of a qualitative analysis of each subject's results, that the superiority of the whole method is a function of the general ability and goodness of memory of the subject (19, p. 172): "Bei den begabteren und leichter lernenden Vpp. zeigte er" (der Vorzug der G-Methode) "sich sofort deutlich, während bei den schwer lernenden Vpp. erst im Laufe der Übung eine Differenzierung der Lernweisen zu gunsten von G eintrat."

The factor of order of recall—whether the stimulus words in the list are presented in the same, or different, order from that of learning—is not correlated with any consistent tendency, since, with different order, Pechstein (No. 3) found the part, but Brown (No. 4) found the whole, superior, while Neumann (Nos. 7, 8 and 9) found the whole most efficient with both same and different order.

In considering Pechstein's results (No. 3), it must be remembered that the criticisms of his experiment made in the discussion of Table I apply here also, since the experimental conditions are the same. Moreover, a valid comparison of his results with those in the other studies in Table III is impossible because of his different learning conditions.

The above analysis of the experimental data upon paired associates suggests that the relative efficiency of the whole and part methods depends upon: form of the method, practice, familiarity or difficulty of the material, type of association tested, and the memorizing ability of the subject.

IV. Poetry—Individual Experiments—Adults—Learning

Table IV summarizes the individual experiments upon poetry to complete mastery with adult subjects. Attention is called to the fact that only two of the four experimental series on adults by Larguier

des Bancels have been listed. The two, which Reed interpreted (**29**, p. 594) as favoring the part method, have been omitted. In these two, the whole method could not have been superior since no whole method was employed. It is clear from the following description of the method which Larguier des Bancels called "globale" that it was misnamed: "Pour appliquer la méthode globale, il lisait et récitait mentalement le morceau d'un trait, et s'il lui manquait un mot, un vers, il était obligé de reprendre le morceau dès le commencement." (**13**, p. 189)

TABLE IV

POETRY—INDIVIDUAL EXPERIMENTS—ADULTS—LEARNING TO COMPLETE MASTERY

(A) *Massed Practice*

Author	S's	Size of Unit	Units per Method	Methods	Superior Method: Time	Superior Method: Repetitions
1. Steffens	1	9 lines	45	W & Natural P	W	No diff.
2. Steffens	4	8–9 lines	24–42	W and P	W 4/4	No diff.
3. Bancels	1	10 lines	3	W & Prog. P	W	——
4. Bancels	1	10 lines	5	W & Prog. P	W	W
5. Pentschew	1	16 lines	10	W & Prog. P	W	W
6. Pentschew	1	16 lines	8	W and P	W	W
7. Pentschew	1	16 lines	6	W and P	P	W
8. Pentschew	1	24 lines	16	W and P	P	W
9. Pentschew	1	32 lines	?	W and P	P	W
10. Pentschew	1	40 lines	1	W and P	Same	W
11. Pyle and Snyder	1	20–25–30–40 50 lines	3–5	W and P	W 5/5	——
12. Lakenan	1	9–18–27	5–20	W and P	P 3/3	P 3/3
13. Lakenan	1	9–18–27–36	20 ?	W and P	——	W 4/4
14. Reed	1	9 lines	10	W & Prog. P	Prog. P	——
15. Reed	1	12 ? lines	20 ?	W & Prog. P[a]	W	——
16. Reed	1	4–24 lines	2–3	W and P	P 5/5	——
17. Reed	113	? lines (4 stanzas)	1	W and P Prog. P	No diff. in av. scores	——

(B) *Distributed Practice*

18. Pyle and Snyder	1	60 lines	2	W	W 2/2	——
		120 lines	1	Prog. P	W	——
		240 lines	1		W	W

The numbers in the last column indicate subjects after Steffens, but experimental series after Pyle, Lakenan and Reed.

[a] Meaning of units destroyed with the progressive part method.

Reed contended (**28**, p. 111) that the results of his experiments (Nos. 14 and 16 in Table IV; No. 3 in Table VII) in which a form of the part method was superior to the whole, "should be balanced against the hitherto published experiments which were made on a small number of subjects," and doubted then, "if any general statement can be made in favor of the whole method." It is not a question, however, of balancing results, since such a balancing would imply coördinate data (*i.e.*, obtained under strictly similar experimental conditions) which the studies in Tables IV and VII do not yield. Again the problem should be analyzed on the basis of the factors upon which the relative efficiency of the learning methods

depend. Lakenan's results (Nos. 12 and 13) suggest that some of the discrepancy in the experimental data might be due to a difference in the amount of practice in memorizing under experimental conditions, since she found, when serving as her own subject (No. 12) that the whole method, which was consistently inferior at first, after some months of practice in memorizing, showed (No. 13) a consistent and considerable superiority—from 8 per cent to 32 per cent. A careful analysis of the relationship between amount of practice, superiority of method and degree of superiority, however, revealed no consistent tendency in these individual experiments. Moreover, the advantage of the whole method in Lakenan's second experiment (No. 13) is not measured in terms of time, but only in repetitions. This excludes the possibility of comparing her results with those of other investigators who have used time scores, and raises the question of the relative merits of the two criteria of learning efficiency—time and repetitions. Pentschew (**25**) contended that the concept of economy in learning method embraces a saving in energy as well as in time. He assumed, as likewise did Meumann (**16**, p. 373), that effort was measured by number of repetitions, and presented, therefore, both repetition and time scores (Nos. 5–10). Just what repetitions measured, however, is doubtful, in view of his explanation (**25**, p. 517), based on observation and introspective reports, of the fact that the whole method required fewer repetitions but longer time: the whole method required a greater concentration of attention which resulted in more fatigue, and consequently slower reading. In this case, then, the method that required the fewer repetitions and therefore, according to his assumption, less effort, is pointed out as producing greater fatigue. Here repetition scores are not only confusing but superfluous: the time scores indicate both the quicker method and the one which produced less fatigue (although requiring more repetitions).

In this connection, Müller's discussion (**18**) of effort as a criterion of economy in learning should be mentioned. He objected to Lehman's contention (in *Elemente der Psychodynamik* III. Teil 1905) that the method which requires the least energy is superior to the one which requires the least time, on the grounds that greater effort (more repetitions) is not necessarily a disadvantage, unless expended in harmful amounts, *i.e.*, unless actual fatigue factors enter.

The main objection, however, to the use of repetitions as a criterion of efficiency is the one pointed out by Reed (**29**, p. 593):

repetitions do not constitute units of constant value, as does time, since their duration varies with the length of the learning material and their number with the rate of reading. The only conditions under which repetitions maintain a constant value are those of equal units of learning material which is presented at a constant rate, and then time and repetitions scores are interchangeable. One cannot, therefore, in Table IV, legitimately compare the results of different experiments by the same investigator, or of the various experiments by different investigators on the basis of repetition scores, since the poetry units varied in length and the rate of reading was not constant.

This objection, not to mention the questionable statistical reliability of her results, invalidates Lakenan's conclusion that the relative advantage of the whole method over the part with poetry (No. 13), and both relative and absolute advantage with prose (No. 1 in Table VII) increases with longer selections, since it is based on repetition scores alone.

If only the time scores are considered then, Pentschew's experiments (Nos. 5–10) suggest a tendency for the efficiency of the method to be a function of the length of the material, since two subjects found the part method superior with 24 and 32 lines (Nos. 8 and 9), whereas, with only 16 lines, two subjects found the whole superior (Nos. 5 and 6). This tendency, however, is not consistent, since another subject (No. 7) with only 16 lines found the part more efficient, while the individual with whom the part was superior with 32 lines (No. 9) showed no difference between the two methods in learning 40 lines (No. 10). Moreover, Pyle (No. 18) found the whole method superior to the progressive part with units of from 60 to 240 lines, but his distributed practice conditions complicate the interpretation of this result with respect to the length of material. He concluded from these data on one subject that the advantage of the whole method is relatively greater with longer selections requiring more than one sitting than it is with shorter selections learned in a single sitting (No. 11). This conclusion can be accepted, at best, as a tentative suggestion, in view of the fact it is based on data from the learning of four selections by only one subject.

Steffens (Nos. 1 and 2) and Larguier des Bancels (No. 3) found the whole method superior in spite of the fact their subjects preferred and spontaneously employed forms of the part method, and several even doubted at the beginning of the experiments that learning could be accomplished by the whole method. These facts

indicate that preference for a method is not a determining factor in its relative efficiency.

The fallacy of generalizing from data on a few subjects is brought out by Reed's results (No. 17) obtained from individual experiments on as many as 113 subjects. The differences here between the average scores for the whole, progressive part and part methods were so small that he considered them, even without statistical treatment, unreliable, and concluded that the efficiency of learning methods is a function of the individual learners, 77 per cent of whom found a part method superior. However, this subsumption of the whole-part problem under the larger one of individual differences aids but little if the factors causing the individual differences remain unanalyzed.

V. Poetry—Individual Experiments—Adults—Retention

The results of the retention tests, which were made on the material learned in the individual experiments discussed above, are summarized in Table V.

TABLE V

POETRY—INDIVIDUAL EXPERIMENTS—ADULTS—RETENTION

Author	No. of Exper. in Table IV	Interval	Sup. in Learning	Superior in Retention
1. Bancels	3	3–9 days	W	W by recall score
2. Bancels	4	7–17 days	W	W by recall score
		24 mos.		W by recall score
		25 mos.		No diff. in R scores (reps.)
3. Pentschew	5 & 6	24 hrs.	W	R–W C–W S–Same (time)
4. Pentschew	7	24 hrs.	P	R–W C–P S–W "
5. Pentschew	8	24 hrs.	P	R–W C–W S–W "
6. Pentschew	9	24 hrs.	P	R–P C–P S–Same "
7. Lakenan	12	24 hrs.	P	Ambiguous results in S (reps.)
		1 year		S–W "
8. Lakenan	13	2–7 mos.	W	S–W "
9. Reed	16	24 hrs.	P	R–P 4/5 C–P 5/5 (time)

It is apparent from the three types of scores, which were computed from Pentschew's relearning data (Nos. 3–6), that the superiority of a method in the retention of poetry is, as it was with nonsense syllables, a function of the method of measurement. Larguier des Bancels (No. 2) found a difference even between a relearning score and a recall score obtained by a prompting method, for there was no difference between the whole and progressive part methods after an interval of 25 months when retention was measured by the number of repetitions required to relearn, whereas a month previously, the whole method had been considerably superior to the progressive part in retention scores based on the number of words correctly recalled. Larguier des Bancels concluded, therefore, that

the relearning method of measuring retention does not bring out the differences between methods. Length of interval is pointed out by Lakenan to be a factor in the difference between methods in retention. She concluded from two experiments (No. 7 in Table V; No. 8 in Table VII) that retention is not adequately tested after 24 hours, since results thus obtained were often reversed after much longer intervals—from 2 to 7 months or one year. These conclusions can be considered only as tentative suggestions in view of the fact they are based on the results of one or two experiments on a single individual.

VI. Poetry—Individual Experiments—Children—Learning and Retention

Table VI summarizes the individual experiments on the learning of poetry to complete mastery by children under massed practice conditions and on retention.

TABLE VI

POETRY—INDIVIDUAL EXPERIMENTS—CHILDREN—COMPLETE MASTERY—MASSED PRACTICE

(A) *Learning*

Author	S's	Age	Unit Size	Units per Method	Methods	Superior Method: Time	Superior Method: Reps.
1. Steffens	1	10	4 lines	48	W and P	W	W
2. Steffens	1	9	8 lines	68	W and P	W	Same
3. Bancels	3	9–12	8 "easy"	1	W and P	W 3/3	W 3/3
4. Bancels	1	9–12	10 "harder"	1	W and P	W	W
5. Bancels	1	9–12	" "	1	W and P	P	P
6. Pentschew	1	12	8 lines	6	W and P	W	W
7. Pentschew	1	12	16 lines	5	W and P	P	W
8. Pentschew	1	10	8 lines	?	W and P	P	W
9. Pentschew	1	8	4 lines	4	W and P	P	W
10. Meyer	8	14	4 lines	36	W & Irreg. P	W 8/8	W 8/8
11. Meyer	8	14	8 lines	36	W & Irreg. P	W 8/8	W 8/8
12. Meyer	4	14	12 lines	12	W & Irreg. P	W 4/4	W 4/4

(B) *Retention*

Author	Learning No.	Interval	Superior in Learning	Superior in Retention		
13. Pentschew	6	24 hrs.	W	R–W	C–W	S–Same
14. Pentschew	7	" "	P	R–W	C–Same	S–W
15. Pentschew	8	" "	P	R–W	C–P	S–W
16. Pentschew	9	" "	P	R–W	C–P	S–W
17. Meyer	10	1–2–3–4 days	W	Ambiguous results		

Inspection of just the time scores, since length and rate of reading of the learning material varied, reveals that the discrepancies in results are accompanied by differences in age of subjects, length and difficulty of material and amount of practice. However, these factors are so inextricably interwoven in the experimental conditions employed that Meyer's investigations (Nos. 10–12) are the only ones

which afford an opportunity to isolate a single factor, which in this case, is length of material. He found with older children, *i.e.*, fourteen years of age, who had had considerable practice, the whole method to be consistently superior with selections of 4, 8 and 12 lines in length, but its advantage decreased with increasing length of material, being 21 per cent, 14 per cent and 5 per cent (in time scores, $\frac{P\text{-}W}{P}$) for 4, 8 and 12 lines respectively. Although the number of his subjects and these percentage differences are small, the consistency of Meyer's results argue for the probability of the tendency he noted. In his attempt, however, to study the effect of recitation on the relative efficiency of the whole and part methods, his experimental technique resulted in an irregular part method in which the divisions of the material varied during learning. For this reason, his results cannot be compared to those of the other studies in Table VI in which the units in the part method remained constant while being learned.

On the basis of the behavior of one subject whose attention was weak and memory poor, Larguier des Bancels suggested (**13**, p. 201) ability of the subject as a factor in the advantage of the whole method: "Il est possible que, chez un sujet, incapable de saisir facilement un ensemble d'une certaine importance, la méthode globale perde sa supériorité."

That the advantage of the whole method over a pure part is less apparent with younger or duller subjects, with longer or more difficult selections or with less practice can be considered, in the light of the analysis of Table VI merely as a possibility.

Before considering the next table, Meyer's analysis of the different modes of attack utilized in the two methods is worth noting. Under instructions which encouraged recitation as soon, and as much, as possible, the whole method proved consistently superior to the part in both time and repetition scores throughout his study—with adults learning nonsense syllables (No. 6 in Table I) and prose (Nos. 4 and 5 in Table VII) and with children learning poetry (Nos. 10–12 in Table VI) and prose (Nos. 6 and 7 in Table VII), although the part method showed greater number and percentage of recitations and earlier use of them. Meyer explained this result on the basis of the difference between the two methods in the

behavior of the subjects while learning. Under part method instructions, readings were hasty and impulsive and were followed very quickly—often after only one repetition—by attempts at recitation. Frequently parts were given more recitations than necessary in order to prevent forgetting while subsequent parts were being learned. Such behavior resulted in an unfavorable score in both time and repetitions for the part method. Contrasted to this, was the more methodical attack in the whole method, in which there was slower reading, greater concentration of attention, more emphasis upon difficult parts and later attempts at recitation.

VII. Prose—Individual Experiments—Adults and Children—Learning and Retention

Experiments on the learning of prose to complete mastery under massed practice conditions, and on retention are summarized in Table VII. The results with prose are substantially the same as those obtained by these investigators with poetry (Tables IV, V and VI) under very similar experimental conditions. Reed's poorly controlled experiment (28) on college students with text book chapters as learning material is not included in the table.

Analysis of the individual experiments on poetry and prose has added to the factors suggested by the review of the work on serial nonsense syllables and paired associates the following factors which might affect the relative efficiency of a method in learning: criterion of learning efficiency, distribution of practice, and rate and character of repetitions (when rate of presentation is not controlled); and length of interval as a possible factor in retention.

TABLE VII

PROSE—INDIVIDUAL EXPERIMENTS—MASSED PRACTICE—COMPLETE MASTERY

(A) *Learning*

Author	S's	Age	Size of Unit	No. per Method	Methods	Superior Method	
						Time	Reps.
1. Lakenan	1	Adult	100–300 words	20	W and P	——	W
2. Lakenan	7	13 ?	100 words	5	W and P	——	W 5/7
3. Reed	1	Adult	200 ? words	20 ?	W and Prog. P	Prog. P	——
4. Meyer	3	Adults	12 lines	21	W and Irreg. P	W 3/3	W 3/3
5. Meyer	15	Adults	20 lines	1	W and Irreg. P	W 13/15	W 15/15
6. Meyer	3	14 yrs.	12 lines	21	W and Irreg. P	W 3/3	W 3/3
7. Meyer	15	13 & 14	20 lines	1	W and Irreg. P	W 12/15	W 12/15

(B) *Retention*

8. Lakenan	No. 1 in learning	Interval 24 hrs.	Ambiguous results—S
		2–7 mos.	S–W
9. Lakenan	No. 2 in Learning	24 hrs.	S–W 4/7

VIII. Poetry—Group Experiments—Adults and Children—Learning and Retention

Table VIII summarizes the group experiments on the learning and retention of poetry. Winch's results (32) are particularly worthy of consideration, since his experiments are the only ones in the whole field of memorizing meaningful material (Tables IV-VIII) which are statistically valid. His careful use of the method of equated groups with the whole and progressive part methods resulted in a reliable superiority of the progressive part with eleven, twelve and thirteen year old school children in learning four short poems under massed practice conditions (Nos. 2–4). His conclusions (32, p. 79), however, that "there seems no doubt, that for school children of these grades and ages, a 'part' method of memorizing poetry of the usual form is decidedly superior to a 'whole' method," is unjustified in its generality. The inferiority of the whole method in his study must be considered in the light of the fact that the habitual learning methods of the children in two (Nos.

TABLE VIII

POETRY—GROUP EXPERIMENTS—ADULTS AND CHILDREN

I. *Learning*—(A) *Massed Practice*

Author	No. and Age of S's	Material	Practice	Methods	Scores	Superior Method
1. Fox	24 adults	14 lines	Reps.	W and P Prog. P	Prompts	No diff.
2. Winch	19 pairs 11–6	4 "short" poems	Time	W Prog. P	Words	Prog. P*
3. Winch	26 pairs 12–8	4 "short" poems	Time	W Prog. P	Words	Prog. P*
4. Winch	10 pairs 13–1	4 "short" poems	Time	W Prog. P	Words	Prog. P*
5. Pechstein	12 8th grade	6–21 lines 7 units per method	C.M.	Repet. P P W Prog. P	Time	Repet. P best: decreasing order under "Methods"

(B) *Distributed Practice*

6. Winch	Same S's as in No. 2	1 "long" poem	Time	W Prog. P	Words	No diff.*
7. Sawdon	7 pairs 12 & 13	3 "short" poems	Time	W Prog. P	Words	W 7/7
8. Sawdon	Same as above	1 "long" poem	Time	W Prog. P	Words	W 7/7

II. *Retention*

		Interval	
9. Fox	Retention on No. 1 above.	1 week	No diff.
10. Winch	Same conditions as in No. 2 above, only 1 "long" poem with distributed practice.	24 hrs.	Prog. P*
11. Winch	Same conditions as in No. 3 above, only 1 "long" poem with distributed practice.	24 hrs.	No diff.*
12. Winch	Another "long" poem with conditions same as in No. 11.	48 hrs. 1 week	No diff.* No diff.*
13. Sawdon	Retention on No. 7 above.	1 month	W 5/7

In the "Practice" column are given the units in which the practice periods were measured; "Time," "Reps." (repetitions) or "C.M." (complete mastery).

* Statistically valid.

2 and 4) out of his three experiments had been forms of the part method. Moreover, as Sawdon (30, p. 191) pointed out, under Winch's experimental conditions the short time given for memorizing permitted only partial learning and consequently favored the progressive part method, since the part learner "has attained some value for the time spent, in a few lines learnt, while the 'whole' learner has only a more or less vague idea of the sense with perhaps a line or two standing out prominently, but very little of the actual words retained." In some preliminary experiments in which he employed the method of equated groups and experimental conditions similar to Winch's, Sawdon found that a small increase in the time allotted for memorizing changed an advantage of the part into a superiority of the whole. Moreover, in his two main experiments (Nos. 7 and 8) the whole method was superior to the progressive part with three short poems and one long one when the children were permitted to study until one of the group indicated that he thought he had mastered the material. Sawdon's results are consistent although his subjects are few and his data are not statistically analyzed. It is unfortunate, therefore, that this superiority of the whole method over the progressive part with longer learning time is complicated by the factor of distributed practice, which prevents a direct comparison with Winch's results. Sawdon concluded that, as a general rule, under his experimental conditions, the whole method will be superior, "provided sufficient time is available." His hypothesis concerning the relationship between time allotted to learning and the relative efficiency of the learning methods should be noted: under his and Winch's experimental conditions, there is a duration of time for each individual below which the whole method is at a disadvantage; at which the two methods are equal; and beyond which the advantage of the whole increases until a period of diminishing returns sets in. Sawdon fully appreciated that his hypothesis, if proven true, would be applicable as an explanatory principle only to those cases in which the time allotted for learning is utilized, with respect to the particular parts of the material, by the subject as he sees fit within the limits of the instructions for each method. It has no bearing, however, on results obtained under other experimental conditions, such as Pechstein's complete mastery (No. 5), or those employed by Fox (No. 1) in which each line of the selection was given the same number of repetitions with every method.

Both Winch and Sawdon concluded that the nature of the poetry learned is a factor in the relative efficiency of the learning methods. Winch found the progressive part method superior in the learning of a long, disjointed, rhymed poem (No. 10), but no reliable difference between methods in a long poem (No. 6) that had continuity of meaning and style and was without rhyme. The factor of the difference in the nature of the poems here is complicated by the difference between the two experiments in the length of the interval before testing. Sawdon concluded from results obtained under the same experimental conditions with the same subjects, that the advantage of the whole method is greater with poems that are easy to understand and continuous in thought than with those that are difficult or disconnected, or without pronounced rhyme or rhythm. This conclusion can be taken only as a suggestion, since both the differences upon which it is based and the number of subjects are small.

Mental ability as a factor in the whole-part problem was brought out by Pechstein (No. 5) and Sawdon (30). Larguier des Bancels' suggestion in 1902 and Neumann's in 1907 that the ability of the subject might be a factor have already been mentioned. In 1911 Müller (18) concluded on the basis of his results on 11 mentally weak subjects, from eleven to thirty-two years of age, with poetry (4 and 8 lines) and serial (8, 10 and 12) nonsense syllables and (8) words that mentally weak subjects, unlike normal individuals, learn better by parts than by wholes. His experimental conditions are too irregular and insufficiently described to permit inclusion of his study in the tabular summaries. Furthermore, insufficient data are published to permit judgment regarding the correctness of his diagnosis of his 11 subjects who were classified as 5 imbeciles, 2 hebephrenics, 2 epileptics, and 2 with mental debility. Interpretation of his results is complicated by the fact that in some of his subjects low intellect was combined with mental disorder. All of his subjects, however, were certainly below normal in intelligence and his data show, with only a few exceptions, a part method to be superior to the whole in learning and retention.

Along with Müller's experiment, Gregor's investigation (10), the results of which are not summarized in the tables, should be mentioned. Gregor concluded that the part method was superior to the whole with two patients suffering from Korsakoff's disease on the basis of results from a series of experiments with lists of 8 items (nonsense syllables and words) and poetry.

In 1926 Pechstein published data (No. 5) on 12 eighth grade school children of unstated chronological ages, who were divided into two groups, of six each, differing in I.Q.: a bright group with an I.Q. range from 125 to 136; and a dull group with an I.Q. range from 80 to 93. On the basis of results on these 12 children, who each learned poetry selections of seven different lengths by four different methods, he announced (**24**, p. 184): "two very definite conclusions: (1) Some form of the part method is best for this type of learning. (2) The intelligence quotient is an essential factor in learning, learners of high intelligence being better able to employ the whole method successfully than are learners of lower intelligence levels. The lower the level, the more difficult to learn by the whole method, and the more ineffective it becomes." An analysis of Pechstein's published data shows that his two conclusions are unwarranted. No individual records are published, but simply the average scores for each group of six, and his data are not statistically treated. From the average time scores published, the writer obtained the following results in 7 comparisons (7 different lengths of material) of the repetitive part method, which is the most efficient of the four methods used according to the tables published, and the whole: with the bright group, the repetitive part was superior in 4 out of 7 comparisons, but the average difference between the two methods was ½ per cent in favor of the whole method; with the dull group the repetitive part was superior in 5 out of 7 comparisons with an average advantage of 10 per cent in its favor. It is very doubtful, therefore, whether there are any reliable differences between the four learning methods *within* each group, much less a difference *between* the two groups in the relative advantage of the methods. The value of Pechstein's study lies in its being the first specific, although unreliable, experimental attack upon the factor of intelligence in the whole-part problem.

Sawdon pointed out in 1927 (**30**) that Winch's data (Nos. 2–4) show a decrease in the advantage of the progressive part method with an increase in the age, school grade and memorizing ability of the subject. Furthermore, the fact that in one of Winch's experiments "the abler boys did much better by the 'whole' method in the longer poems points to the conclusion which Winch hints at but does not definitely formulate, that the greater the mental development the more will the 'whole' method tend to show its value" (**30**, p. 186). The comparisons upon which this conclusion is based are relatively few, but the statistical validity and consistency

of the differences between learning methods with the four short poems (Nos. 2–4) argue for the probability that "mental development" (as measured in terms of age, school grade and memorizing ability) is a factor in the relative efficiency of the whole and part methods.

As a result of the above analysis of the group experiments on poetry, two factors should be added to those already suggested: length of time given for learning (under certain experimental conditions), and mental ability of the subject.*

IX. Acts of Skill—Adults—Learning

Table IX summarizes the experiments on the learning of seven types of skill under laboratory conditions. Retention was not studied in any of these investigations.

On the basis of experiments with his particular maze, Pechstein (**20**, p. 65) was "inclined to argue from his results to the general motor field." Examination of Table IX reveals that further experimentation has not justified this inclination. Roughly comparable procedure and practice conditions on different motor problems have given contradictory results. Furthermore, the following analysis of the experiments of Pechstein and Barton will show that,

TABLE IX

ACTS OF SKILL—ADULTS—LEARNING

Author	Material	Av. No. S's per Group	Practice Periods in	Methods Ranked in Decreasing Order
1. Pechstein	Maze	6	Trials Distributed	Prog. P W P
2. Pechstein	Maze	6	Complete mastery Massed	Prog. P P W
3. Barton	Maze	10	Time Distributed	P best* Direct Repet. W
4. Mather and Kline	Cardboard puzzles	2	Time Distributed	P superior to W
5. Koch	Finger sequences	45	Time Distributed	P superior to W*
6. Gopalaswami	Mirror-drawing	10	Trials Distributed	Prog. P P W
7. Barton	Typing	15	Time Distributed	W superior to P*
8. Brown, R. W.	Piano scores	?	Trials Distributed	W Combination P
9. Crafts	Card-sorting	20 ?	Trials Massed	W superior to P*

* Statistically valid.

* McGeoch, Grace O., The Intelligence Quotient as a Factor in the Whole-Part Problem. *J. Exper. Psychol.*, 1931, 14, 333–358.

even in the field of maze learning, generalizations in regard to the relative efficiency of various learning methods cannot be made.

Pechstein's data (Nos. 1 and 2) show that the progressive part method was superior to both whole and pure part methods with both massed and distributed practice. The superiority of the whole over the part was a function of the distribution of practice: with distributed practice, the whole was superior, while massing the practice rendered the part more efficient. Among others, he made the following conclusions: (**20**, p. 58) "the inherent advantages of 'part' learning are mainly the complete utilization of the transfer items and the avoidance of diminishing returns due to the excessive length of the motor problem"; (**21**, p. 308) "all waste in part learning occurs in the act of connection and is here traceable almost entirely to the influence of place assocation"; (**20**, p. 58) "the inherent advantages of 'part' learning, together with the elimination of place associations, explain the universal superiority of 'modified part' methods in motor learning." In considering Pechstein's results and conclusions two points must be kept in mind—the number of his subjects and the nature of his maze. Here, as in his experiments with nonsense syllables (Tables I and III), he employed the method of equated groups, using only six human subjects (and not many more rats) in groups which were simply assumed to be equal in maze learning ability. Since he did not publish individual records, one cannot judge how typical of the group and how reliable are the average scores on six subjects who have learned but one sample of the type of problem used and by only one method. Pechstein's maze was constructed to give great similarity (measured by length of true pathway, number of culs-de-sac and relative position of final cul-de-sac) between units. He explained that (**20**, p. 51) "the maze had been designed with a view of establishing a partial identity of detail for the four sections, so that this element of specific transfer might be partially tested." Pechstein did find evidence of both general and specific transfer in the part methods, and gave the following example of the latter: errors caused by the final cul-de-sac in the last three sections, Nos. 6, 9 and 12, were "especially numerous" with the whole method, while, with the part "Nos. 6 and 9 were rarely entered and No. 12 practically not at all." Since the maze has been so constructed that transfer was greatly facilitated, and since (**20**, p. 57) "transfer factors operate at their full in 'part' procedure," it is not surprising that, under practice conditions favorable to transfer, *i.e.*, massed,

the part methods were superior with Pechstein's maze. It is probable, however, that maze patterns involving dissimilar units might give different results.

Unfortunately Barton's investigation (No. 3), the only other study on a maze, throws no light on this problem, since (1, p. 427) "the parts of the maze are very much alike," and therefore the positive transfer between units which he obtained, "should be expected." Barton found that the pure part method was superior to both the whole and a direct repetitive. In so far as statistical treatment can be applied to groups of ten, this advantage of the pure part is statistically reliable, *i.e.*, the differences are over three times the sigmas of the differences, which were computed by the writer. On the basis of this superiority of the pure part method over both a modified part and the whole, with distributed practice, Barton made the following criticism of Pechstein (1, p. 427): "What has been said about the 'positional establishments' when the units are being connected, as an explanation of the waste in 'part' learning can have no point in this experiment; because the 'part method' is, by far, the best of the three methods here used. There is no waste to be explained . . ." It should be pointed out that Barton's distributed practice conditions are irregular with respect to the units of the maze, since practice periods were equated in time instead of in trials, as in Pechstein's study. Such an irregularity in distribution might have had a differential effect on the three methods used. However, Pechstein did not limit his explanation to his particular set of experimental conditions, but is comprehensive in his generalization (21, p. 308): "it seems apparent that all the waste in part learning occurs in the act of connection." (A recent experiment of Crafts (No. 9) which will be taken up shortly, also attacks this generalization of Pechstein.) The only two investigations on mazes, although both employed distributed practice, have yielded contradictory results: Pechstein found the whole superior to the pure part, while Barton's data show the reverse. Therefore, as was pointed out before, Pechstein's conclusions have not been proved to hold even in the narrow field of maze learning, much less "in the general motor field," as an examination of the other studies in skill will show. The experiments will be taken up in chronological order.

The investigation of puzzle solving by Mather and Kline (No. 4) barely deserves mention because of the number of subjects—two

groups of two each. It might be noted in passing that the part method, but not the whole, is here correlated with positive transfer (in time scores) between the units, which were similar to the extent that they had been built according to a general principle.

Koch's study (No. 5) of learning finger sequences on a typewriter keyboard dealt with the simultaneous integration of simpler or part reactions in contrast to all the other experiments on the whole-part problem in skill, which have studied successive integration only. The number of subjects and the statistical reliability of the results make significant her conclusions that the part method, under these conditions, is superior to the whole by the criteria of time and trials but not by the error criterion. Since her whole method, however, amounted to the simultaneous formation of two habits, *i.e.*, one habit by each hand, and the part method a successive mastery of the same two habits, her study is not coördinate with the other whole-part experiments. It more appropriately belongs to the problem of the formation of more than one habit.

Gopalaswami (No. 6), using a star pattern in mirror-drawing, interpreted his results as corroborating those of Pechstein: with distributed practice (9, p. 229), there is "a considerable superiority of the progressive part method," "greatest inferiority of the whole method," while the pure part (with greater massing) is intermediate. This corroboration, however, is valueless, since the differences between the averages of the methods employed are not only small but unreliable. The published table of individual records shows almost complete overlapping of the scores for the three methods and the sigmas of the differences (computed by the writer) are larger than the obtained differences. It is rather surprising that a difference of 7 per cent between mean scores (9, p. 229) for groups, of not over ten each, should be considered large enough to "indicate" the above conclusions, whereas, in another section of the paper (9, p. 236) a difference of 10 per cent between average scores is passed over as showing "no advantage." The smallness of his groups renders all of Gopalaswami's results of questionable validity. The writer computed the sigmas of the differences between those groups which had as many as ten subjects and found none of them reliable. Here, the publication of individual records afforded an opportunity for statistical analysis which is impossible in Pechstein's study. In spite of the questionable validity of Gopalaswami's results, however, it is interesting to note that the part method, if not reliably superior,

is, at least, probably not inferior, to the whole method in a motor problem the pattern of which was divisible into quarters of equal number of diagonal and vertical lines and of (9, p. 228) "sufficiently equal difficulty." Here again, a certain similarity of units is correlated with efficiency of the part method.

Barton (No. 7) in an experiment on typing found that the W group, who were taught by (2, p. 10) "the comprehensive process of beginning and continuing the practice on complete composition material that is most like that which the typist will be required to use" in practical work, were considerably superior to the P group, who were taught by "the synthetic process of beginning with isolated and meaningless letter-symbol combinations and gradually going from these to the more simple words, phrases and sentences, and finally to the use of the business letter and other composition forms." The differences in terms of two criteria of efficiency, final score and average number of letters written per practice period, are statistically valid.

The whole method was again found superior to the part by R. W. Brown (No. 8) in learning musical scores. Her data are hard to evaluate since they are not statistically treated and neither the number nor the proficiency of the subjects is mentioned.

Crafts (No. 9) following Barton, has also called into question Pechstein's generalization in regard to all the waste in part learning occurring in the act of connection. He argued (5, p. 545) that in the non-serial reactions involved in card-sorting where there are few, if any, definite acts of connection to be acquired, the difficulty associated with such acts is at a minimum, and, therefore, the part method should have opportunity to display the "inherent advantages" which have been attributed to it. However, under conditions of massed practice (under which, according to Pechstein (20, p. 65) "the 'part' methods are always more efficient") Crafts found in simple card-sorting that the whole method was in general superior to both pure and modified part methods. Complex card-sorting yielded the same results only in more pronounced degree. This fact calls into question another of Pechstein's conclusions (23, p. 94): "The longer and more difficult the problem, the more advisable to break it up into units . . . it being uneconomical to learn the hard problem as a whole, irrespective whether effort is massed or distributed." Crafts pointed out that, although both types of card-sorting are classifiable as easy problems, nevertheless,

if Pechstein's contention were true, one would expect the whole method to be less advantageous in the harder of the two problems. As stated above, the opposite condition was found. Crafts drew the following conclusions (5, p. 563), which deserve particular attention in view of the large number of his subjects and the statistical validity of the majority of his comparisons: "(1) that the crucial reason for the inferiority of a part method need not in all cases reside in this matter of serial connections (even though it may in part be found in failure to master relations other than serial); (2) that a combination or progressive part method is not necessarily superior to a whole method, even in the field of motor learning; and (3) that in consequence existing generalizations to such effect stand in need of qualification." The nature of Craft's card-sorting problem precluded the possibility of specific positive transfer between its units. Under these conditions of dissimilar units, the whole method, which gave the greatest opportunity for the simultaneous integration of the various relations involved into a complete pattern, was definitely superior to the part method in which the pattern was integrated through cumulative additions.

It should be noted that the last three investigators in Table IX, working on three different types of skill, have found the whole superior. The efficiency of the whole method here might be partly a function of the nature of the problems—their indivisibility into similar units between which specific positive transfer could occur—or the resultant of other experimental conditions. Similarity of units of the material and the correlated factor of the kind and amount of transfer should be added to the list of factors which have already been suggested.

Summary

A critical analysis of the experimental data of 30 investigations, in only 6 of which the results are statistically valid, has suggested that the relative efficiency of the whole and part methods in learning and retention is a function of, at least, the following factors:

1. Subjects—age, training, memorizing ability and intelligence.
2. Material—type, nature, difficulty and length.
3. Practice—amount, and distribution and nature of practice periods.
4. Form of the part method used.
5. Method of measuring learning efficiency.

6. Method of measuring retention efficiency.
7. Length of interval.

Experimental data, at the present time, do not justify any generalization regarding the specific or mutual effect of these factors.* The studies on memorial material (Tables I-VIII), however, yielded a somewhat consistent tendency for the advantage of the whole method to be more apparent with subjects of more mental ability (because of greater age, intelligence, or memorizing ability) and after practice.

The conclusion regarding the whole-part problem that logically follows is that there is no inherently superior method: the absolute and relative efficiencies of any given method are the complex resultant of the pattern of experimental conditions in which many factors are differentially and reciprocally effective.

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